The Search for Superheavy Elements

The Discoveries of Elements 114, 116 and 118

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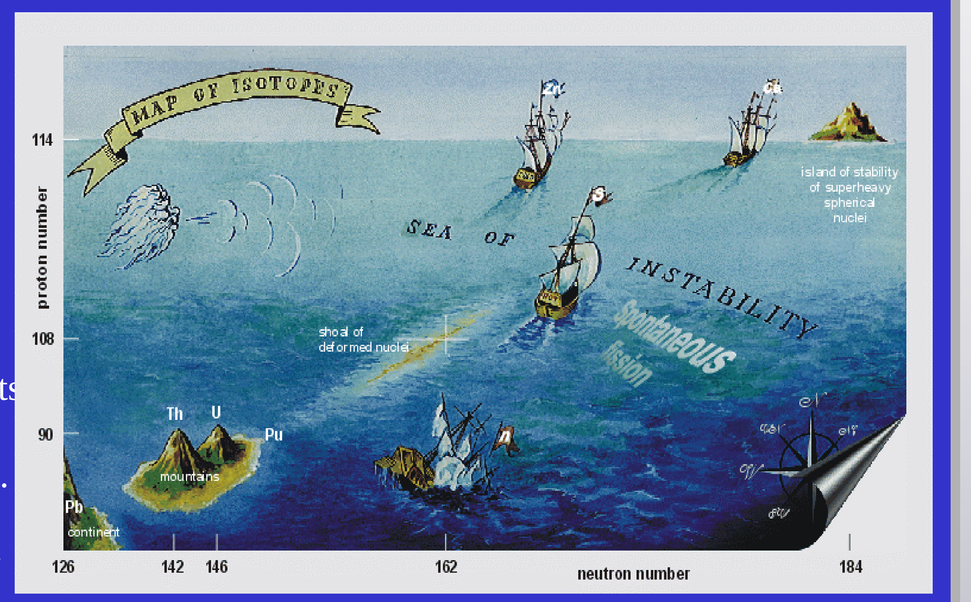
Introduction



One of the outcomes of nuclear structure theory and the shell model is the possible existence of an "Island of Stability". This Island of Stability resides beyond the heaviest known stable isotopes of lead and bismuth, beyond the long-lived isotopes of uranium and plutonium. The only possible way of observing these superheavy elements is through their production using heavy ion beams and stable/long-lived isotope targets. Various theoretical calculations have been performed over the past 35 years that show the Island of Stability resides somewhere near Element 114, near the predicted closed shells Z = 114 and N = 184. This "Island of Stability" has been reached using ^{48}Ca ion beams and highly enriched plutonium, curium and californium targets.

Results

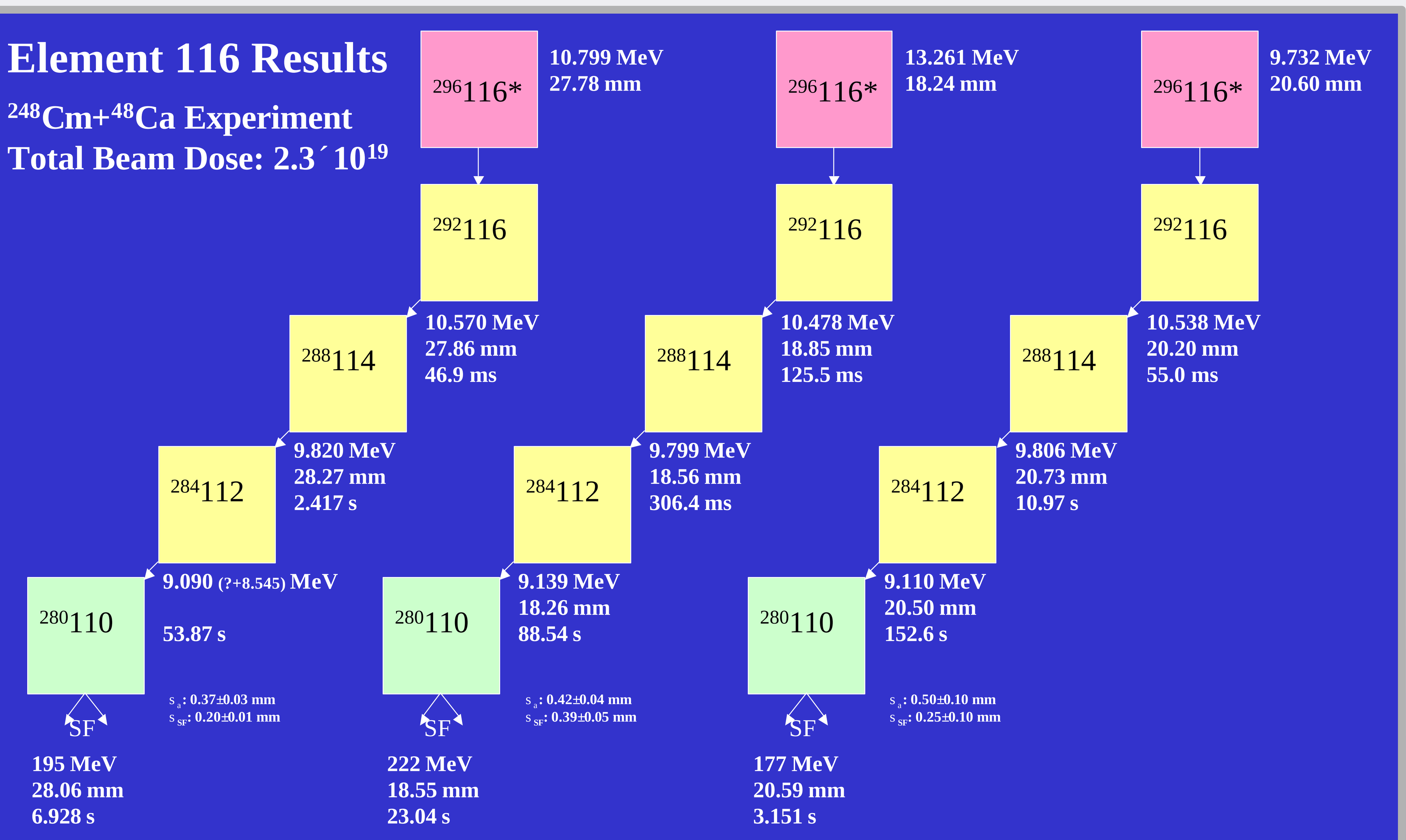
During several experiments over the past 5 years, 1 atom of isotope $^{289}114$ was observed and 2 atoms of $^{288}114$ were created in experiments with ^{48}Ca ion beams and ^{244}Pu targets. 3 atoms of isotope $^{292}116$ were created in experiments with ^{48}Ca ion beams and ^{248}Cm targets. Each of the 3 $^{292}116$ atoms alpha-decayed through $^{288}114$ with energies and lifetimes similar to those observed in the reactions that directly produced $^{288}114$. 1 atom of $^{294}118$ has been observed with the possibility of another event from 118 also being observed. In the second experiment to produce 116 using a ^{245}Cm target, 5 atoms of $^{290}116$ have been observed. Finally, a second run using ^{244}Pu targets was completed and a total of 17 new atoms of various isotopes of 114 were observed.

Element 114 Results

$^{244}Pu+^{48}Ca$ Experiment
Dose: 1.5´10^19

Element 116 Results

$^{248}Cm+^{48}Ca$ Experiment
Total Beam Dose: 2.3´10^19



<u>Preliminary</u> Element 118 and Element 116 Results

$^{249}Cf+^{48}Ca$ Experiment Dose: 2.5´10^19 **$^{245}Cm+^{48}Ca$ Experiment Dose: 1.2´10^19**

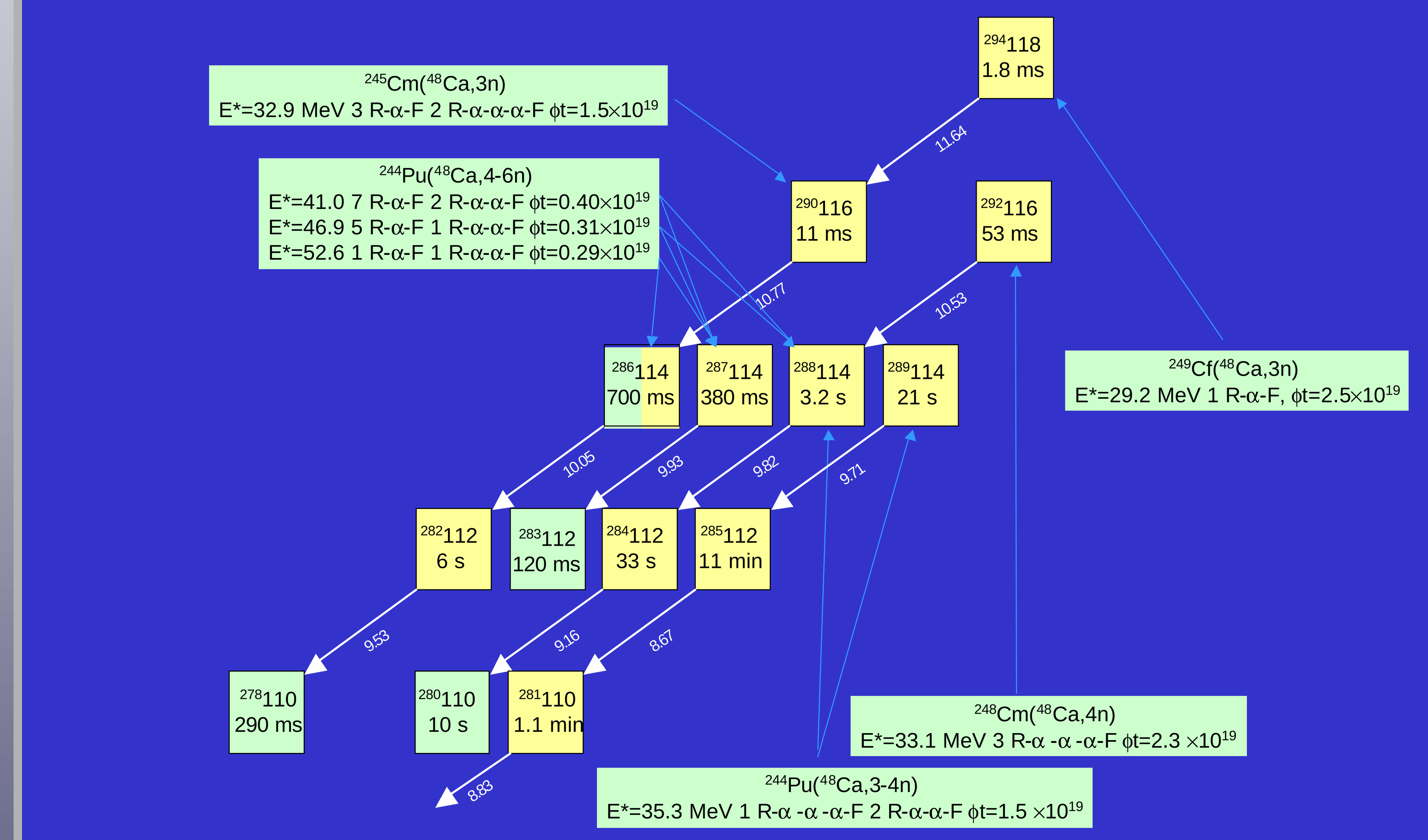
Additional Experiments

Based on the successes of the experiments to produce Elements 114, 116 and 118, an attempt was made to measure the excitation function for the 244Pu+48Ca reaction. In addition to the first energy measured in 1998-1999, three additional energies were run to complete the excitation function for this reaction.

E*: 35.3 MeV, 1 Recoil-α-α-α-SF, 2 Recoil-α-α-SF
E*: 41.0 MeV, 0 Recoil-α-α-α-SF, 2 Recoil-α-α-SF, 7 Recoil-α-SF
E*: 46.9 MeV, 0 Recoil-α-α-α-SF, 1 Recoil-α-α-SF, 5 Recoil-α-SF
E*: 52.6 MeV, 0 Recoil-α-α-α-SF, 0 Recoil-α-α-SF, 1 Recoil-α-SF, 1 Recoil-α-α-SF

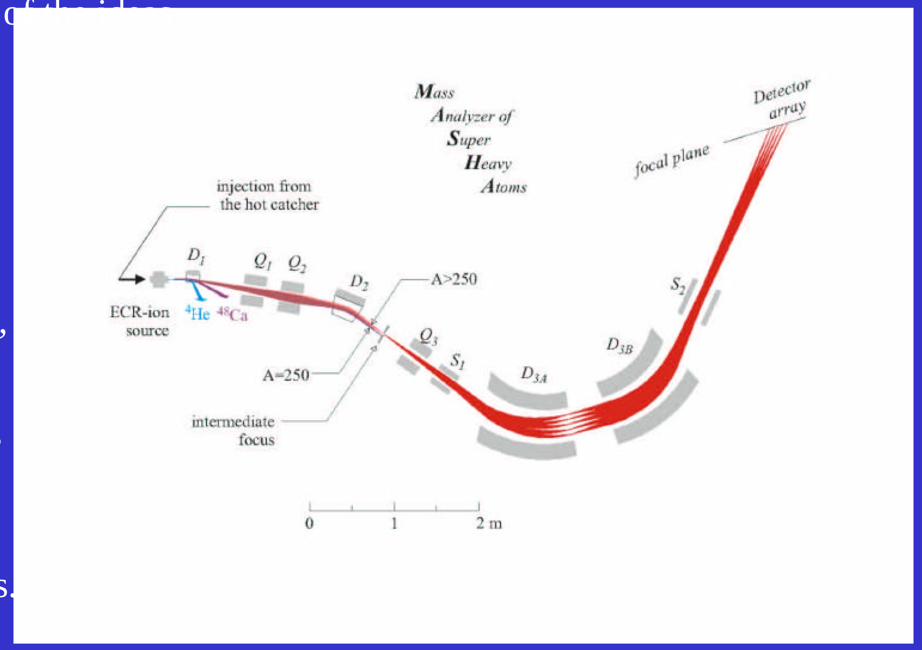
The decay chains are listed in a manner to illustrate chains with similar decay energies and lifetimes.

Summary/Chart of the Nuclides



Future Heavy Element Experiments

In the past, new isotopes of heavy elements were discovered through their connection to known isotopes through their decay daughters. To overcome the difficulties inherent in identifying new isotopes of heavy elements when there is no connection to known isotopes, another means is needed to positively identify the Z of these new elements. One of the ideas proposed in our collaboration is the use of a mass analyzer to separate out lower Z atoms to focus only certain Z elements on a focal plane detector. MASHA or <u>M</u>ass <u>A</u>nalyzer of <u>S</u>uper <u>H</u>eavy <u>A</u>toms will take recoils from the collision of a ^{48}Ca beam and a ceramic uranium or plutonium target, ionize them and accelerate them through a series of magnets, finally being focused onto a focal plane detector. It is the aim of this apparatus to positively identify new isotopes of the heavy elements through a direct correlation of decay energy and mass.



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